

SECTION III.—FORECASTS.

FORECASTS AND WARNINGS, FEBRUARY, 1918.

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The severe weather of the winter 1917-18 came to a close temporarily in the Northwest on the 4th, the great interior valleys on the 5th, and Atlantic coast districts on the 6th. After about a week of moderate temperature a cold wave, the second of the month, moved across the country, beginning in the Northwest on the 13th and reaching Atlantic coast districts on the 16th. Another cold period set in on the 17th, reaching Atlantic coast districts on the 21st, and finally a short and less intense period began on the 24th and ended on the 26th.

Between these several cold periods the weather was warm—so warm, indeed, that notwithstanding the great thickness of ice on the rivers and the heavy snow cover that was on the ground in the beginning of the month the ice went out of the streams, except the more northern ones, and the snow disappeared without causing severe floods in any part of the country.

East of the Rocky Mountains the weather of the month as a whole may be characterized as moderately dry, with periods of rapidly alternating temperature; west of the Continental Divide the month was wet, especially along the coast, with temperature close to the seasonal average.

PRESSURE OVER THE PACIFIC AND ALASKA.

Daily reports of pressure, temperature, wind, and weather were received from two points in the Pacific, Midway Island, north latitude $28^{\circ} 13'$, west longitude $177^{\circ} 22'$; and Honolulu, north latitude $21^{\circ} 19'$, west longitude $157^{\circ} 52'$. The stations reporting by cable or radio from Alaska number nine, most of which are coast stations, although the interior was represented by the station at Eagle, Alaska, north latitude $64^{\circ} 46'$, west longitude $141^{\circ} 12'$. Since the westernmost station in the United States proper does not exceed 125 degrees west longitude, it is seen that Alaskan reports give early information of the eastward march of weather conditions from the Pacific. These reports, in connection with those from the two points first named, continue to be of foremost interest to the forecaster.

The accidental pressure variations over the Pacific and over continental areas seem to be of different type: that is to say, the oceanic type as illustrated by Midway and Honolulu is different from the continental type in the following-named particulars: The oceanic type is more steady as measured by the less frequent occurrence of accidental changes and the greatly diminished amplitude of the variations. When these changes are portrayed graphically with time as ordinates and the variations above and below the normal as abscissæ, the resultant graph in the case of the oceanic type presents a smooth, well-rounded profile, while the graph representing continental areas presents a jagged, irregular outline.

Pressure at Midway was low on two occasions during the month, viz, from the 1st to the 4th and again from the 18th to the 24th, both inclusive. Pressure was high—that is, above normal—from the 4th to the 18th and from

the 25th until the end of the month. The variations at Honolulu did not very closely parallel those just described, the most important variation being from the 14th to the 18th, when fairly high pressure prevailed at Midway, with the reverse conditions at Honolulu. It so happened that the lowest sea-level pressure of the month at Honolulu, 29.66 inches, on the 17th, occurred at a time when the pressure at Midway, as cabled, was 30.18 inches. Unfortunately reports from the southwestern islands of the Aleutian group for this date were missing: hence the supposition that the great area of high pressure, central over interior and the northwestern coastal region of Alaska, extended southwestward over the Pacific is more or less speculative. The Midway High seems to have advanced eastward, but the low pressure at Honolulu seems to have been coincident with a shallow depression that appeared off the Washington coast on the p. m. of the 16th. The track of this depression is platted as No. VII, Chart III. Two days after the occurrence of the barometric minimum at Honolulu a shallow depression appeared off the coast of north central California, where it remained 48 hours, and finally filled up. This depression appeared at a time when a strong anticyclone from Alaska was passing southeastward along the eastern slope of the Rocky Mountains. (See No. V, Chart II.) The combination—strong HIGH over northeastern Rocky Mountain slope, shallow LOW over California—is the ideal condition for winter rains in California, and much-needed rain fell on this occasion.

Finally, it may be remarked that pressure in Alaska was not uniformly high or low throughout the month, but that a period of low pressure especially well marked at Valdez, prevailed from the 1st to the 13th. During a part of this time, pressure was also low in interior Alaska. But beginning on the 12th, high pressure developed over Nome and spread southeastward, overspreading both coast and interior stations and endured without a break until the 20th. During this period of high pressure in Alaska two HIGHS, with the usual fall in temperature moved southeastward over the United States.

The most severe cold of the month occurred, however, at a time when pressure in Alaska had been unusually low for some days. The cumulative evidence of the month points to the conclusion that severe cold weather in the United States is not necessarily dependent upon high pressure and cold weather in Alaska as an antecedent condition.

HIGHS.

Eight principal HIGHS and three offshoots therefrom have been platted on Chart II.

The origin of these HIGHS may be placed, approximately at least, as follows: Four in western Manitoba, northwest of Lake Winnipeg; one in central Alberta; and three over the Pacific, west of the Oregon and north California coast. It is interesting to note that only two of the northwestern HIGHS occurred when pressure over Alaska was moderately high and that the remaining three occurred with either low pressure or nearly normal pressure over Alaska; also, that high area No. I, ap-

parently originated in west central Manitoba when pressure was low in Alaska. This HIGH caused a sharp drop in temperature and abnormal cold in its course to the east and south. The paths of the northern interior HIGHS was at first south and then eastsoutheast. The HIGHS which entered the continent from the Pacific, Nos. *III*, *VI*, and *VII*, moved generally in an easterly direction although they too have a slight southerly component of motion after crossing the Rocky Mountains. The northward loop in the path of No. *III* is probably due to the influence of local topography and elevation. The southeastward portion of the track probably represents the course of an offshoot from the original high in which central pressure increased from 30.36 inches on the coast to 30.74 inches at Yellowstone Park, Wyo., 48 hours later, and thereafter steadily diminished.

High area No. *V* showed the greatest pressure of the month, viz, 31.08 inches. This high level was reached wholly within the United States. On the morning of the 19th, the crest of the HIGH was 30.60 inches at Edmonton, Alberta. On the next morning it was in the upper Missouri Valley, covering parts of the three States, Montana, North and South Dakota, with central pressure of 31.00 inches and an average temperature of -30° F. The 24-hour rise in pressure over this area was a little more than 0.75 inch, or nearly double the rise at points in the Canadian Northwest. An explanation of this sharp rise in pressure over a considerable area when pressure was already at a high level would be exceedingly interesting and instructing. It does not seem likely that the weight of the column of air over the upper Missouri Valley could have been increased by the inflow of air from adjacent regions. If there had been such a flow, pressure would have fallen in the region from which the air was removed. Since no fall appeared within the field of observations, it would seem that the cause of the rise in pressure must be sought elsewhere. Prof. Humphreys has suggested that the flow of air southward in a HIGH, if vigorous, may so interfere with the normal eastward drift of the atmosphere as to cause a congestion or damming effect and thus produce higher pressure over the regions where the damming effect is most pronounced. The subject needs further observation and study.

LOWS.

The paths of 10 primary and 4 secondary LOWS have been platted on Chart III. Six of these LOWS apparently originated in the Province of Alberta, three over the North Pacific west of Oregon and Washington and one near Lake Winnipeg, Manitoba. The paths followed by these LOWS—see Chart III—were closely in accord with previous experience. The speed of movement was unusually high. The tendency for a secondary LOW to develop to the southward and a little in the rear of the primary when the last named decreased in intensity was well illustrated during the month. Low No. *III* appeared off the coast of Washington on the morning of the 6th. Evidently it divided during the day since on the night map two centers appeared, one in British Columbia with lowest pressure 29.10 inches, the other over southern Nevada with central pressure at 29.84 inches. The northern LOW moved rapidly eastward and disappeared beyond the field of observation toward Hudson Bay on the night of the 7th. Meanwhile the Nevada depression had crossed the Rocky Mountains, increasing in intensity and moved thence rapidly northeastward to Newfoundland as a moderately severe storm.

Again, Low No. *IV*, appearing in the far Northwest, with central pressure of 29.60 inches, had developed into a long barometric trough by the forenoon of the 11th. A vigorous secondary appeared in the southwestern end of the trough and moved rapidly northeastward during the ensuing 48 hours.

North Pacific Low No. *VII* appeared on the coast of Oregon on the 8 p. m. map of the 16th with central pressure 29.68 inches. This Low advanced steadily and crossed the high mountains of Colorado on the 18th. On the 8 p. m. map of that date sealevel pressure at Pueblo, Colo., altitude 4,713 feet (1,436.5 meters), a station in the lee of the high Rockies immediately to the westward, was 29.24 inches and the temperature was 56° F., 18 degrees above the seasonal average. On the west side of the mountains as at Grand Junction, Colo., altitude 4,602 feet (1,403 meters), sealevel pressure was 29.28 inches and temperature 40° F., but 3 degrees above the seasonal average, with a south wind showing that the weather west of the mountains was still under the influence of the Low. At the same hour a fairly strong anticyclone was moving southward along the eastern slope of the Rocky Mountains, its front being approximately 100 miles north of Pueblo, Colo. The temperature gradient between the center of the LOW and the southern front of the anticyclone was at least 0.3° F. per mile for a distance of probably 120 miles.

A pressure configuration as thus described can lead to but one result, viz, the elimination of the low center either partially or entirely and the formation of a new low center farther to the east or south. In this case a center of low pressure remained west of the mountains for 24 hours and eventually disappeared and a new center appeared as shown on Chart III, track No. *VII*. Further remarks on this formation will be submitted at a later date.

Low No. *VIII*A appeared on the morning of the 24th as a depression over Montana in the rear of primary Low No. *VIII*, central at the time over Lake Superior with central pressure of 29.14 inches. This primary LOW passed rapidly eastward and pressure in the central region rose to 29.62 inches in 24 hours. In the meantime the secondary advancing as a long oval-shaped depression with two centers of low pressure, reached Lake Huron by the afternoon of the 25th with central pressure 28.80 inches attended by moderate southerly gales and thunderstorms in its southern portion and snow with northwest gales in the northern portion. The pressure continued to fall during the night as the storm passed down the St. Lawrence Valley. On the morning of the 26th, the barometer had fallen to 28.68 inches at Quebec. Fortunately this great depression of the barometer was not immediately followed by anticyclonic conditions and the temperature remained moderately high for the season after its passage.

The outstanding features of interest in connection with February LOWS are (1) the development of a secondary in each case, as the primary decreased in intensity, (2) the rapidity of movement of the LOWS, especially of the rain area in their eastern front.

WARNINGS.

Storm warnings were issued for various parts of the Atlantic coast on February 3, 4, 8, 9, 12, 14, 19, 20, 25, and 26. The warnings of the 25th were for a whole gale from the Delaware Breakwater to Boston. Advices were also sent to open ports on Lake Michigan on the 3d, 13th, and 25th.

Cold-wave warnings were issued for various portions of the Washington forecast district on the 3d, 4th, 13th, 14th, 15th, 19th, and 20th, and special advices as to temperature conditions were issued on the 1st and 19th.

Two warnings of intensified northeast trades were issued for the Canal zone on the 4th and 19th, respectively.

The following velocities were reached:

Feb. 4.....	24 miles per hour, NE.
Feb. 5-6.....	26 miles per hour, NE.
Feb. 19.....	28 miles per hour, NE.
Feb. 20.....	26 miles per hour, NE.
Feb. 21.....	30 miles per hour, NE.
Feb. 22.....	27 miles per hour, NE.

WARNINGS FROM OTHER DISTRICTS.

Chicago, Ill., forecast district.—The first cold wave warning of the month was issued for eastern Minnesota on the evening of the 2d, at which time an active disturbance of small extent was moving eastward over Minnesota, while an area of high pressure and low temperature was advancing southward over Manitoba. On the following morning the warnings were extended eastward over Wisconsin. These warnings were fully verified.

On the morning of the 13th a disturbance of marked intensity was central over Wyoming and an area of high pressure and low temperature was overspreading Manitoba and Saskatchewan. Cold-wave warnings were issued for North Dakota, northern Minnesota, and eastern Montana. During the afternoon and evening the warnings were extended southward over Wyoming and the Plains States and eastward over western Wisconsin, western and central Iowa, and northwestern Missouri. On the 14th warnings were issued for eastern Wisconsin and extreme eastern Iowa. Cattle warnings were issued for Wyoming and the Plains States on the 13th. These warnings were verified over the greater portion of these States.

Warnings were issued well in advance of the cold wave which overspread the greater portion of the district during the 18th-20th. The only warnings during the remainder of the month were those for North Dakota and portions of Montana, Minnesota, and South Dakota on the 24th. These warnings were only partially verified.—*Chas. L. Mitchell, Forecaster.*

New Orleans, La., forecast district.—Low temperatures attended an area of high pressure extending from the Plains States eastward over the Mississippi Valley and the Lake region on the 1st and the barometer being relatively low over Florida, cold-wave warnings were ordered for southeastern Louisiana. The cold did not reach southward to the Gulf coast. Another cold-wave warning ordered for southeastern Louisiana on the 3d was not verified because the pressure continued low in the west Gulf causing easterly winds to prevail.

An intense low-pressure area was centered over Kansas on the night of the 13th and the barometer was rising over the northwest; cold-wave warnings were ordered at 9:30 p. m. for Oklahoma, were repeated on the morning of the 14th and extended to northwestern Arkansas. Later in the day, the warnings were extended over Arkansas, northwest Louisiana, and northern Texas. The high pressure area and cold weather did not move as far south as was expected, and while a decided fall in temperature occurred, the verifying temperatures were not recorded except over the northern portion of the area covered by the warnings.

The a. m. weather map of the 15th showed an area of low pressure over the southeastern Rocky Mountain

region and an intense high-pressure area over the British Northwest. Expecting the low-pressure area to move southeastward and under the anticyclonic area, cold-wave warnings were ordered on the 15th for the interior of Texas and on the 16th for Louisiana and the Texas coast. The low-pressure area moved southeastward as was anticipated and there was a decided fall in temperature but the warnings were only partially verified.

On the a. m. of the 18th, an area of low pressure was centered over Utah and an area of high pressure attended by low temperature was moving southward from the British Northwest. Cold-wave warnings were ordered for the Texas Panhandle, 9:40 a. m., advising live-stock interests that the temperature would be 10° to 16° on the morning of the 20th. Cold-wave warnings were issued at 9:45 a. m. on the 19th for Oklahoma, the Texas Panhandle and northwestern Arkansas, were extended in the afternoon and at night to the Gulf coast and repeated for the coast stations on the morning of the 20th. The warnings were fully verified over the interior of the district and partially verified on the coast.

Cold-wave warnings were ordered at 2:30 p. m. on the 27th for Oklahoma and northern Texas and repeated at night for Oklahoma. The temperature fell 30° to 40° but the warnings were only partially verified.

No cold waves or severe weather conditions occurred without warnings.

Southeast storm warnings were ordered for the west Gulf coast on the 27th and were verified on the Texas coast.

Fire-weather warnings were issued on a few dates for both Oklahoma and Arkansas and high winds occurred as forecast.—*I. M. Cline, District Forecaster.*

Denver, Colo., forecast district.—Cold-wave warnings were not required during the forepart of the month. On the morning of the 14th an extensive anticyclone occupied the Canadian Northwest, attended by temperatures close to zero in eastern Montana and North Dakota. Cold-wave warnings were issued for eastern Colorado, and repeated for the extreme eastern portion of that area in the evening as the pressure was still rising on the eastern slope. These warnings were only partially verified although temperatures as low as 6° to 10° above zero occurred in eastern Colorado on the 15th. On the 17th a North Pacific storm moved southward to southern Utah. On the morning of the 18th the barometer reading at Modena was 29.28 inches, and an anticyclone had moved into Montana from the Canadian Northwest. Cold-wave warnings were issued for northeastern Colorado. On the evening of the 18th the storm was over Colorado and the warnings were extended to include southeastern Colorado and northeastern New Mexico. The warnings were fully verified, except in the extreme western portion of northeastern New Mexico. The fall in temperature on the 19th was more than 30°, with zero temperatures in northeastern Colorado. During the night of the 18th-19th the storm divided, leaving an area of moderately low pressure in western Colorado. Meanwhile the anticyclone had been reinforced by high pressure from Alberta. Cold-wave warnings were repeated on the morning of the 19th for southeastern Colorado and extended to include all of eastern New Mexico. The warnings of the 19th were fully verified in the greater portion of eastern New Mexico and zero temperatures prevailed in portions of southeastern Colorado. Cold-wave warnings were also issued for eastern Colorado on the evening of the 24th. Although the temperatures were 20° to 30° lower in eastern Colo-

rado on the 25th they were not low enough to verify the warnings.

Warnings of strong winds were issued for considerable areas on the 6th, 7th, 13th, 17th, 18th, 24th, and 27th and were generally accurate, notably on the 13th and 14th when velocities of 40 miles per hour were reported in portions of New Mexico, 40 to 60 miles in Utah and 48 to 52 miles in Colorado; on the 18th when velocities of 52 miles occurred in southwestern Utah and 46 to 48 miles in New Mexico; and on the 27th when velocities of 30 to 64 miles were reached in New Mexico.

Freezing temperature was forecast for south-central Arizona on a few dates, and temperatures close to the freezing point occurred, except on the 9th when lower temperatures failed to accompany rising pressure.—*Frederick W. Brist, Assistant Forecaster.*

San Francisco forecast district.—February, 1918, in the Pacific States was not unusually stormy and transportation by sea and land suffered little interruption. During the last half of the month the long drought in California was broken by a rainy spell that lasted for a week or more, and the month closed with a drying "norther" that did no great harm, being of short duration.

There were many frosty mornings, but vegetation suffered little harm, as most crops were in a dormant state and those that were not dormant were for the most part protected by smudge fires or other means.

Storm warnings were ordered on 15 occasions at one or more stations; small craft warnings were ordered 4 times for limited stretches along the coast; live-stock warnings were sent to stockmen in Washington, Oregon and Idaho on the 4th, 6th, and 17th; and frost warnings were issued on 13 occasions to places in California. In addition to the general warnings of frost, special attention was given to a localized service for citrus fruit in the neighborhood of Pomona, Cal., where for the first time an

attempt was made to foretell exact minimum temperatures about 12 hours ahead of their occurrence. This service was quite successful and sufficient data have been obtained this season to warrant the belief that more accurate minimum-temperature forecasts can be made for that locality next year.

The general frost forecasts were only partially successful and several frosts occurred without being predicted, due in nearly every case to a quick and unexpected clearing of the weather at about sunrise.

During the first half of the month gales were most frequent along the North Pacific coast, and during the last half most frequent along the California coast. Most of the storm warnings were fully verified, and only one for the coast of northwestern California, ordered on the 13th, was a complete failure. Small-craft warnings were justified in every case, and so far as known the live-stock warnings were timely and of value to stockmen.

Three notable failures occurred in the daily weather and temperature forecasts for northern California. Two of them were due to the retreat of a high pressure area off the southern California coast, which at the time the forecast was made seemed to be moving inland, in which case fair weather would ensue; but for some unknown reason a few hours after the morning reports were received these HIGHS retreated seaward far enough to permit northern California to come under the influence of low-pressure areas, and as a result considerable rain fell in the northern half of that State. (See a. m. charts Feb. 12-13.) The third failure was due to a low pressure area of marked intensity, the front edge of which was first noted on the morning of the 19th near Eureka. This storm before night caused general rains in California. Its subsequent movements were forecast with a fair degree of accuracy.—*E. A. Beals, District Forecaster.*